

**ISSUED** June 14, 1966

CLASS 166-16

GROUP

CANADA

CLASSIFICATION

# CANADIAN PATENT

LINER EXPANDER

Joe C. Stall, Tulsa, Oklahoma, U.S.A.

Granted to Pan American Petroleum Corporation, Tulsa, Oklahoma, U.S.A.

APPLICATION No. 897, 460

FILED

PRIORITY DATE

No. OF CLAIMS

#### LINER EXPANDER

10

20

30

This invention relates to a constant force spring device, and more particularly, to a device for expanding a metallic liner wherein an expanding die is urged against the liner by a constant force spring device.

Heretofore, a method and apparatus have been developed for installing an expanded metallic liner in an oil well or other conduit. Typically, a corrugated steel liner is inserted in a conduit which is to be lined, the greatest peripheral dimension of the liner being slightly less than the inside diameter of the conduit. An expanding tool is passed through the liner placed in the conduit, and a first-stage expanding die causes a gross plastic deformation of the liner, which is expanded outwardly against the inside of the conduit. A second-stage die on the tool then provides an additional finer deformation of the liner to provide a smoother, more finished surface on the inside of the liner and to assure more complete contact between the conduit and the liner. In a typical design of this type expanding tool, the frictional drag of the first-stage die supplies the expanding force for the second-stage die, which expanding force is a direct function of the strength, or wall thickness, of the conduit in which the liner is being installed. For example, in lining oil well casing, heavy wall casing may cause a very high frictional force which results in excessive pressure being required to push the expander through the liner. The application of the great forces required may result in rupture of the casing or in breaking the installing tool. In instances where the internal diameter of the conduit is somewhat less than that anticipated, the resulting forces can cause the tool to become stuck in the casing, or otherwise cause damage to the casing and the tool. In other designs, such as where a cantilever spring arrangement is employed in connection with the secondstage die, various difficulties are encountered in obtaining a spring mechanism having the desired strength in combination with the other spring characteristics, and with the tool dragging against the inside wall of the conduit after being passed through the liner.

Since tools of the type mentioned above often are cmployed in wells deep in the ground, it is highly preferable that a tool be used which under no circumstances will become stuck in the well or cause damage to the well. Any such trouble occurring in a well can result in considerable loss in time and great expense in making repairs.

An object of the present invention is a device for applying a constant force to an expanding die or other similar apparatus so that a preselected maximum force is exerted against a work piece. Another object is an improved expanding tool for installing metallic liners in a conduit, which expanding tool can apply no greater than a predetermined force to the liner being installed in the conduit. Still another object of the invention is an economical and easily fabricated constant force spring device. A further object is a rugged, easy-to-operate expanding tool employing such a spring device. These and other objects of the invention will become apparent by reference to the following description of the invention.

In accordance with the present invention there is provided a constant force spring device which comprises a body member, an elongated column element adjacent said body member, bearing plate members contacting the two ends of said column at least one of said bearing plate members being longitudinally movable in respect of the other and stop means on said body member to limit the deflection of said column element to prevent permanent deformation of said column element upon the application of a compressive load thereto. In one embodiment of the invention, the foregoing constant force spring device is employed in a tool for expanding a metallic liner inside a conduit, said constant force spring device being positioned on said tool to urge an expanding die member against the liner being installed in the conduit by a substantially constant force.

My invention will be better understood by reference to the following description and the accompanying drawings wherein:

Figures 1A, 1B and 1C, taken together, constitute a partial sectional view of a preferred embodiment of a liner expanding tool according to the present invention; and

Figure 2 is a sectional view of the apparatus of Figure 1A taken at line 2-2; and

Figure 3 is a typical plot of applied Load versus Deflection for the constant force spring device of the invention.

10

20

30

٠Ł

Referring to the drawings, Figure 1A is the bottom portion of a liner expanding tool for use in installing a metallic liner in a well, while Figure 1B illustrates the middle section of such a tool and Figure 1C represents the upper section of the tool. The expanding tool 11 is attached to standard well tubing 12 by coupling 13 and, typically, may be lowered from the surface through a well casing (not shown) to a point in the casing at which it is desired to install a metallic liner. Before inserting the tool into the well, an elongated vertically corrugated liner 14 fabricated from mild steel, or other suitable malleable material, is placed on the tool. The corrugated liner is secured in position by contact at its upper end with a cylindrical shoulder member 16 and, at its lower end by contact with a first-stage expanding die 17 in the form of a truncated circular cone which serves as a firststage expanding die in the manner hereinafter described. The expanding die is fixedly attached to a centrally located, elongated cylindrical hollow shaft 18 which forms a portion of the body of the tool. As shown, the expanding die 17 is held in place between a lower shoulder 19 and collar 21 threaded onto the shaft. A plurality of movable arms 22, preferably provided with outwardly enlarged portions 23 near the top, are disposed in the form of a cylinder around shaft 18. The enlarged portions of the arms 25 upon being moved outwardly contact the liner to perform the final step of expanding the corrugated liner into a substantially cylindrical shape. The arm members 22 are pivotally attached to the shaft so as to be movable outwardly from the shaft by a tapered expanding member 24 slidably positioned on the shaft to serve as a second-stage expander. The surface of the member 24, as shown, moves upwardly along the shaft to engage with the arms and move them outwardly. Advantageously, the inside surfaces of the arms 22 and the outside surface of expanding member 24 form mating sections, typically octagonal in shape. The expansion of the arm members is controlled by the position of the member 24 which moves upwardly

until it contacts shoulder 26 provided on the shaft. As member 24 moves in a downwardly direction arms 22 fold inwardly toward the shaft. The expanding arms 22 are held in place on the shaft by collar 27 and circular groove 28 provided on the shaft.

The expanding tool, comprising the first-stage die and the secondstage die is drawn through the liner to expand it in place in the casing. The
first-stage die provides a gross deformation of the liner so that it is
expanded outwardly against the wall of the casing. The second-stage die then
passes through the liner and performs the final expansion to smooth the inner
surface of the liner and to provide more even contact between the liner and
the wall of the casing and effect a fluid-tight seal.

10

20

In operation, the liner setting tool is assembled at the surface, as described above, and a glass cloth saturated with a resinous material may be wrapped around the corrugated tube to form the liner. The assembly is lowered into the well at the location at which the liner is to be set. A liquid, such as oil, is then pumped under pressure down the well tubing and flows through the passageway 29 provided in polished rod 31, through ports 32 and into cylinder 35 connected to the upper end of the shoulder 16. Upon the application of fluid pressure to the cylinder, the piston 34 secured to polished rod 31 moves upwardly in cylinder 33. As shown, rod 36 connects polished rod 31 and shaft 18 upon which is mounted the first-stage expanding die 17. When the piston 34 moves upwardly through the cylinder 33 the expanding die 17 and the secondstage die 22 are drawn upwardly into the corrugated liner 14 and "iron out" the corrugations in the liner, so that the expanded liner may contact the inside wall of the casing in which it is being installed. Positioned on the shaft below the expanding member 24 is a constant force spring member 37 which is employed to urge the expanding member against the expanding arms 22 with a substantially constant force. The force exerted against the arm members being substantially constant, the force transmitted through the arm members to the liner and to the casing will be substantially constant so that either sticking of the tool in the casing or rupture of the casing is precluded. Of course, the force provided by the spring member is preselected so that the frictional

. A .

20

forces between the tool and the liner and the pressure exerted against the casing are maintained at predetermined safe levels. The constant force spring member assures that the contact pressure between the liner forming portion 25 of the arms 22 is great enough to provide the desired deformation of the casing, while preventing damage to the casing or to the tool.

The constant force spring member 37 is slidably mounted on the shaft 18 and held between the expanding element 24 and a cylindrical lower shoulder member 38 forming a portion of a differential screw element 39 which transmits the loading on spring member 37 to shaft member 18. The differential screw element comprises shaft member 18 on the outside of which are cut male threads 18a, the lower shoulder member 38 provided with female threads 38a and thimble member 41 provided with threads 41a and 41b on the outside and the inside, respectively, to engage with threads on the shaft and the shoulder. The two sets of threads are coarse, such as square, modified square, or Acme threads, to withstand very high loads and differ in pitch so that shoulder 38 is moved upwardly on the shaft 18 when the shaft is revolved relative to thimble 41. The shoulder 38 is secured to the shaft 18 by splines 45 so that it can slide longitudinally, but it is not free to rotate on the shaft. Fixedly attached to the lower end of the thimble is a friction member, such as bow springs 42, a hydraulically actuated friction pad, or other such device for frictionally engaging with the inside wall of the conduit to secure the thimble against rotation with respect to the shaft. Preferably, the direction of the shoulder member threads 38a is the same as that of the shaft threads 18a, e.g. righthand threads, and the pitch, or lead, of threads 18a is slightly greater than that of threads 38a, with the pitch ratio being close to unity. In this manner, clock-wise revolution of the shaft relative to the thimble causes shoulder member 38 to advance upward slightly and a compression load is exerted upwardly on spring element 37 to cause buckling. For example, one satisfactory differential screw was made up using five and one-half threads/inch square threads on a shaft approximately 1.7-inch outside diameter and five and threequarters threads/inch square threads on a shoulder approximately 2.5-inches inside diameter.

Constant force spring element 37 comprises column element 45, advantageously consisting of a plurality of elongated columns disposed around shaft 18. Upper bearing plate member 44 is in contact with the upper ends of the columns and is slidably positioned on shaft 18 to transmit the force of the spring longitudinally against the bottom end of expander member 24. Lower bearing plate member 46 contacts the lower ends of the columns and is moved upwardly along the shaft by longitudinal movement of lower shoulder 38 as a result of revolving differential screw element 39. Grooves 47 are provided in each of the bearing plates, to form an upper race and a lower race, into which the ends of the columns are inserted. These grooves may be shaped to conform with the shape of the column ends if desired. A cover 48 may be employed to exclude foreign matter from the spring mechanism and to protect the spring.

10

20

30

A means for limiting the deflection of the columns is required. Although the column element functions in a buckled condition, application of excessive compressive load thereto would cause total failure or rupture of the columns. Therefore, a pair of stops 49 and 49a are provided for this purpose. As shown, the stops are rigidly connected to the bearing plates, and, in effect comprise upper and lower limiting sleeves positioned on the shaft to slide longitudinally thereon. The ends of the stops may move toward, or away from, each other as the load on the spring member varies. Lover sleeve 49a is prevented from moving down by lower shoulder 38 connected to the shaft 18. However, the spacing between the ends is such as to limit the longitudinal travel of the bearing plate members as they move together to prevent permanent deformation of the column element 43. Various alternative means for preventing damage to the column element may also be employed. For example, pins or rings mounted on the shaft may serve as stops, or the cover 48 provided with suitable connections may be employed for this purpose to limit longitudinal and/or lateral deflection of columns.

The columns of the column element 43 may be arranged around the shaft 18, which as shown here forms a portion of the body of the spring device, with ends of the columns fitted in the races 47. The columns may be

fitted closely together as shown, or may be spaced around the race, with separators used between them to maintain the desired spacing. The number of columns employed will depend upon column characteristics and the materials of construction. For example, the slenderness ratio of the column may be varied widely, and the column ends may be round, flat, fixed or hinged. The preferrei construction is a thin, slender column with rounded ends, free to move within the races shaped to the curvature of the column ends. Materials which may be satisfactorily employed for the columns are carbon and low alloy steels, chromium and nickel-chromium stainless steels, various copper base alloys, such 10 as phosphor bronze, beryllium copper, the high nickel alloys and other similar materials providing satisfactory mechanical properties. Typically, the individual columns are of long rectangular cross-section, with the width being greater than the thickness, and arranged so that the wider face of the columns is normal to the diameter of the shaft. Thus, with sufficient compression loading, the columns buckle, and bend about the axis having the least moment of inertia, e.g., outwardly away from the shaft lo.

For example, a group of columns 0.167-inch thick by 0.438-inch wide by 10.626-inches long, with the ends rounded, were fabricated from A.I.S.I 4340 steel, quenched and drawn at 575°F. Each column was found to require a 20 critical compression loading of 450 pounds in order to buckle the column. After buckling, the columns were found to have a very flat spring characteristic, as shown in Figure 3, wherein  $\mathbf{P_c}$  is the critical buckling load and point C represents the load and deflection at which the stress in the extreme fibers of the column exceed the yield point of the material. Theoretically, the shape of this spring characteristic curve is described by curve OA'ABC. Actually, this curve is described by OABC due to friction in the system. Points A and B represent typical working limits, which, of course, may be varied according to the application for which the spring is designed. For example, where a large number of flexing cycles are not anticipated, a working stress just below the 30 yield point may be used, while with a great number of flexures, the working stress may be held to less than the endurance limit of the material of construction. In the above-mentioned tests, the lateral deflection was limited to

spproximately one inch, at which the longitudinal deflection was approximately: 0.225 inches. From zero deflection to the maximum deflection, the 450-pound loading was found to be substantially constant.

In another test a spring device was built, as shown, employing 20 columns, each having a critical buckling load of 1250 pounds. The lateral deflection was limited between 0 and about 1.00 inches by appropriately positioning the stops. Upon compressional loading, the spring element buckled at substantially 25,000 pounds and from a longitudinal deflection of 0.04 inches (buckling) to about 0.15 inches the load remained substantially at 25,000 pounds.

10

30

Of course, in designing a spring element as above it is advantageous to obtain the greatest possible value of longitudinal deflection for specified values of lateral deflection and critical buckling load, while maintaining the stress level in the columns at a safe level. The preferred columns, therefore, are laminated, as shown in Figures 1B and 2, with multiple flat members making up each column.

In the operation of the above expanding tool for setting a liner in well casing, the made-up tool is lowered into the well as mentioned above, with the arms 22 in the retracted position. When the tool is at the desired level, the well tubing is revolved. The friction member 42 engages with the wall of the casing and prevents thimble 41 from revolving. With several revolutions of the tubing, lower shoulder 38 is moved upwardly by differential screw 39 to buckle spring element 37 which has a predetermined critical buckling load. This load is transmitted upwardly against the lower end of expander 24, and its tapered surface is engaged with the tapered surface on the inside of the arms 22 to urge the arms outwardly with a substantially constant force proportional to the critical buckling load of the spring element. Subsequently, the expanding tool is passed through the liner to expand it in the casing in the manner described hereinbefore.

The foregoing description of a preferred embodiment of my invention has been given for the purpose of exemplification. It will be understood that various modifications in the details of construction will become apparent to

the artisan from the description, and, as such, these fall within the spirit and scope of my invention.

-9-

#### I CLAIM:

1

2

3

5

6

7

8

9

10

1.

3

5

6

7

A

- 1. A device for expanding a metallic liner inside a conduit which 1 device comprises a shaft element, an expanding die member attached to said 2 shaft element, said die member comprising a movable liner-forming member 3 Ŀ positioned on said shaft and being radially movable in respect thereof to contact said liner, an expander member slidably positioned on said shaft 5 6 between said shaft and said die member to move said liner-forming member from said shaft, and a constant force spring member positioned on said shaft 7 8 to contact said expander member and to maintain said expander member against 9 said liner-forming member, whereby said liner-forming member is urged against 10 said liner by a substantially constant force.
  - 2. In a device for installing an expanded metallic liner in a conduit wherein an expanding die is moved through a liner positioned in said conduit to expand said liner: a cylindrical shaft element, an expanding die member attached to said shaft, said die member comprising a plurality of arm members disposed around said shaft and being pivotable outwardly therefrom to contact said liner, a come member slidably positioned on said shaft between said shaft and said arm members to urge said arm members outwardly from said shaft, and a constant force spring member positioned on said shaft to contact said cone member and to maintain said cone member in contact with said arm members, whereby said arm members are urged outwardly by a substantially constant force.
  - 3. The device of Claim 2 wherein said constant force spring member comprises a plurality of columns disposed around said shaft, a first bearing plate member and a second bearing plate member, each of said bearing plate members contacting opposite ends of said columns, at least one of said bearing plate members being movably positioned on said shaft and being in contact with said cone member, stop means connected to said shaft to limit the axial travel of said movable bearing plate member along said shaft, and compression means for maintaining a lateral deflection in said columns.

- 4. The device of Claim 3 wherein said compression means comprises
   a differential screw connecting said spring member and said shaft.
- 5. The device of Claim 3 wherein said stop means comprises a

  sleeve-like element connected to said movable bearing plate member and

  slidably positioned on said shaft and a member connected to said shaft to

  limit the travel of said sleeve-like element.
  - 6. The device of Claim 3 wherein said columns have a rectangular cross-section, the width being greater than the thickness, and having the wider face normal to the diameter of said shaft.
  - A device for installing an expanded metallic liner in a conduit which comprises a cylindrical shaft element; an expanding die member mounted on said shaft, said die member comprising a plurality of arm members disposed circumferentially around the outside of said shaft and being pivotable outwardly therefrom to contact the liner; a conical expanding member slidably positioned on said shaft between said shaft and said arm members to urge said arm members outwardly from said shaft; a plurality of slender columns, each having a long rectangular cross-section and disposed circumferentially about said shaft; an upper bearing plate member and a lower bearing plate member, each slidably positioned on said shaft and contacting opposite ends of said columns; limiting sleeves attached to each of said bearing plate members and slidably positioned on said shaft; a shoulder member on said shaft; a differential screw element connecting said shoulder and said shaft to apply a buckling load to said columns; said shoulder being engageable with the limiting sleeve connected to said lower bearing plate member, whereby the axial travel of said bearing plate members is limited; said column members transmitting their buckling load to said arm members to urge said arm members outwardly with a substantially constant force.

1

2

3

l

2

3

4

5

6

8

9

10

12

13

14

15 16

1.5 1.5 Kent

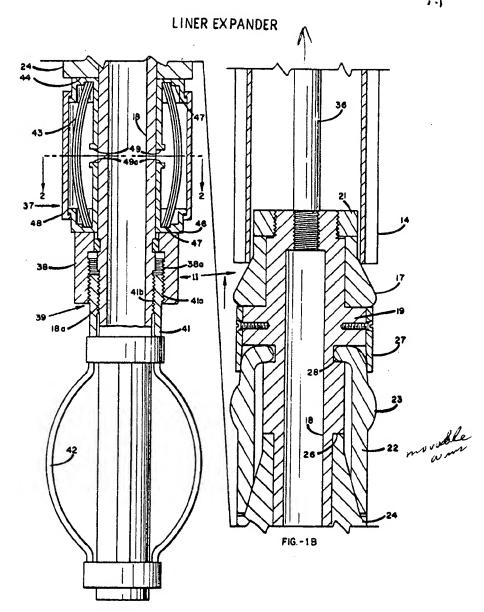
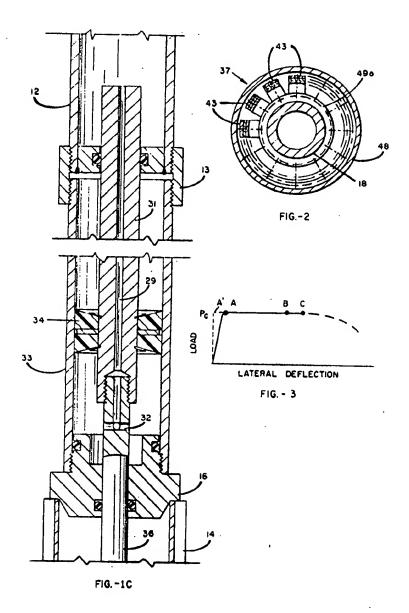


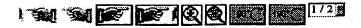
FIG.-1A



Sorry, the requested images for patent number 736288 are unavailable.

O Her Majesty the Queen in Right of Canada, 1999

Canada http://strategis.ic.gc.ca



I CIÁINS

A. A device for expending a metallic line; inside a condité which device comprison a shaft alment, an expending the number extended to said shaft closest, said die number comprising a sevelle liner-forming member pacitioned on said shaft and being endally novelle in respect thereof to contact said liner, an expender number alidably positioned on said shaft between said shaft and paid die number to move said liner-forming number from said shaft, and a constant flows spring number positioned on said shaft, and a constant flows spring number positioned on said shaft, and a constant flows spring number positioned on said shaft, and a constant flows spring number is unyout against said liner-forming sember in unyout against said liner-forming sember in unyout against said liner by a substantially constant force,

e. In a device for installing an expended metallic liner in a conduct wherein as expanding die is moved through a liner poritional in sale sometit to expend said liner; a cylindrical start alement, an expanding die meaber attached to said shart, said the meaber computing a plurality of any members disposed around said shart and being pivobable entertly therefore to contact said liner, a come sember alidably positioned on said start between said shart and said am members to vary said arm members colourely from said shaft, and a comment force spring number positioned on said start to contact said come sember and to maintain said come number in contact with said arm members, whereby said arm technics are urged outpart(by by a substantially constant force.

3. The device of Claim 2 wherein said content force spring content congriscs a plantity of columns disposed around said shaft, a first boaring plate senter and a second bearing plate scaber, each of said bearing plate scabers contenting opposite code of said columns, at least one of said tearing plate members bring reveally positioned on said shaft and being in content with said come member, stop means commerced to said start to limit the axial traval of said southle bearing plate member along said shaft, and compression memors for maleralisations a lateral destaction in said columns.

B

10





- . A. The device of Claim 3 wherein said compression groups comprises a difformation survey commenting mid spring number and said shaft.
- 5. The device of Chain 3 wherein said shop means comprises a share-like element commercial to said seventh twenting plans sembar and circularly gentialess on said shart and a sunface communical to said shart to light the transact of said missess-like element.
- 6. The device of thats 3 whereis said column have a meetingular cross-section, the width being greater than the thickness, and bening the wider flow moved to the dissector of mild shart.
- 7. A device for installing at expended metallic liner in a combuit which comprises a cylindrical shaft classical to account mounted on mid shaft, said the sembar comprising a planshity of are southern disposed cirmsfarantially around the outside of said shaft and being pleotable outerstrum to excitent the liner; a scalest expending measur slidebly him agus os bredum ern him hos stade hime meanted theda him so he are senters octuardly from suid shaft; a plurelity of elender columns, cash bewing a long reutrangular orosa-sertion and disposed sireutranstially shout suid chaft; an upper bearing plate member and a lower bearing plate suster, each slikelly positioned on said short and compacting opposite onds of each columns; limiting alseres whiched to each of said bearing plate members and slidsbly positioned an sedd staft; a shoulder number on said shaft; a differential sower elected connecting will shoulder and said shorts to apply skiling look to said eminus which thousand being companied with the limiting miners commerced to entil larger bearing plate mester, whereby the arial travel of said bearing plate numbers is limited; said column washers branesitting their bunkling look to said arm members to urgs said arm grobers estaurally with a substantially constant force.

17

A



A



#### 736288

#### LITTER EXPLICIT

This invention calcius to a constant force spring device, and nore particularly, to a device for expending a establic liner wherein on expensing die is urged against the litter by a sourcest force against device.

Benefuture, a saturd and apparatus here been developed for installing on separated solution inter in an cal woll or other operation. typically, a sorregated about liner is imported in a conduct think is in he hired, the greatest parighosal-dissection of the liner being slightly less then the lumine diameter of the ecrebial. In expending book is persent through the liner placed in the conduit, and a first-stone expanding disses a gross plantic dofumetion of the liner, which is expensed outwardly against the inside of the conduit. A seagon-stage die on the took than provides on additional firmer defermation of the lines to provide a smoother earn finished surface on the incide of the liner and to secure some complete con the conduit and the liner. In a typical design of this type emending tool, the frintional dreg of the first-stage die supplies the expending force for the second-stage die, which expending force is a direct function of the strength, or wall thickness, of the conduit is which the liner is being installed. For example, in limity oil well cosing, heavy well maying any source a very high trintional fource statch results in excessive are hoing required to push the expender through the liner. The prime set 70 venture at 1500er perimper second dwarp at 10 solder or in breasing the installing tool. In instances there the internal har of the conduct is nonrobet is so then thet articipated, the resulting forces our cours the tool to boom stuck in the casing, or otherwise mage to the ensing and the tool. In other dealgns, such as there a quantilerent spring arrangement is amplayed in scameraton with the secondstigm dis, verious difficulties are encouranted in obtaining a spring aise baying the desired strength is combination with the other spring characteristics, and with the tool dranging against the ingride well of the mondule after bring passed through the liner.



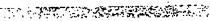
Rince tools of the type mentioned above of the are employed in wells deep in the ground, it is highly preferable that a tool be used which under no circumstances will become stack in the well or same damage to the well. Any such trouble occurring in a well see remail in considerable loss in time and great capacity in making repairs.

As object of the present invention is a fevice for applying a convent force to an expending all or etner similar expension so that a presented maximum force to asserted against a work piece. Another object is as improved expending teel for installing metallic liners is a sandath, which community tool our apply so greater them a predetermined force to the liner heing installed in the conduit. Still another object of the invention is an economical and enaily fabriculed acceptant force spring device. A further object to a regard, easy-to-operate expending tool conjugues such a spring device. These and other objects of the invention will become apparent by reference to the fallowing description of the invention.

In acceptance with the present invention there in provided a conwhent force spring device which comprises a holy meaher, an alongsted online
element adjacent said body meaber, bearing plate numbers contexting the two
work of said column at linest one of said bearing plate members being longiso tutinally movehic in respect of the other and stop means on said body missber
to limit the defination of said solumn almost to provent parameters deformating of said solumn almost most the application of a compressive load
thereto. In one adjustment of the invention, the foregoing assessmit force
spring device is emplayed in a tool for expending a setallic lines inside
a subduit, said complement force spring device being positioned on said tool
to unp as expending the sender against the lines being installed in the
conduct by a substantially constant force.

My invention will be better understood by reference to the following description and the accompanying drawings wherein:

Pigered M., 18 and 10, taken together, conviltute a partial sectional visu of a preferred embediment of a liner expending tool according to the present investion; and



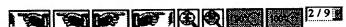
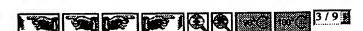




Figure 2 is a sestimon) when of the apparates of Figure 1A taken at time 2-2; and

Figure 5 is a typical plut of applied lock versus Deflection for the constant force spring device of the towartion.

Referring to the drawings, Figure 14 is the bottom portion of a liner expending tool for one is installing a metallic liner to a well, while Figure 19 Likertrotes the middle section of such a took and Figure 10 teproseats the upper sevidos of the tool. The expending tool 11 is attembed to stantant well tubing 18 by compling 15 and, typically, may be lowered from the surface through a well ensing (not shown) to a point in the sweing at which it is desired to install a metallic liner. Before inserting the test into the well, an alongsted wartically corrupted liner is Cabricated from mild steel, or other suitable mileable meterial, is placed on the bool. The corrupted liner is occured in position by contact at its upper end with a cylindrical shoulder member 16 and, et the lower and by contact with a first-stage expansiing dis 17 is the form of a trumoured circular core which serves as a firststage expending die in the second barringfur described. The expanding die is fixedly spherhed to a centrally located, elongated mylintrical hollow short 18 which forms a portion of the body of the tool. As shown, the expending \$40 17 is held in place between a lower shoulder 19 and coller 2) threaded onto the sheft. . A plurality of morphic arms 89, preferably provided with outserfly sularged portions 48 sear the top, wie disposed in the form of a sylinder ad shart 18. The enlarged purbloss of the arms 23 work being soved outvarily contest the liner to purform the final step of expanding the morrageted r into a substantially sylintrical shaps. The are members 22 tro protally etteched to the sheft so as to be sovehile subsertly from the sheft by a tapared expending momber 26 slidsbly posttioned on the sheft to serve as a second-stage expender. The serieum of the meaber 3h, as shown, moves upwardly along the shaft to sugage with the area and more them outwardly. Advantageously, the inside surfaces of the area 22 and the outside excluse of expanding member 24 form sating sentions, typically octogonal is shape. The expension of the arm members is controlled by the postition of the member 20 raich moves upwardly



A PROPERTY OF THE PROPERTY OF THE PARTY OF T

- 3 .

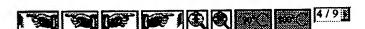


#### ¥36288

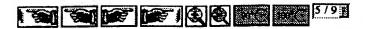
entil) it contacts obscious 26 provided on the chaft. As member it wower in a documently direction area 52 feld invertily toward the shaft. The expending sizes 22 are held to place as the shaft by collect 27 and currelar groups 20

The expending tool, comprising the first-stage die and the secondstage die is drewn through the liner to expend it to place in the caming. The first-stage die provides a gross deformation of the liner so that it is expended convertly against the wall of the easing. The second-stage die then passes through the liner and performs the final acpeauses to emoth the liner surface of the liner and to provide more even contact between the liner and the well of the caming and effect a finid-light soal.

In operation, the liner setting tool is assembled at the surface, so described shore, and a glass cloth saturated with a resumper material may be trapped around the corrugated into to form the liner. The assembly is lovered into the well at the location at which the liner is to be set. A liquid, such so oil, is then peoped under pressure down the soll inhing and flows through growy 29 provided is polished rol 51, through ports 52 and into exitamedeted to the upper and of the shoulder 16. Upon the application of finid programs to the sylinder, the pieton 34 secured to polimbel red 31 nowe openfully in againster 35. As shown, rot 36 numberts polithed rod 31 and sheft 18 spon shieh is mounted the first-stage expending die 17. Then the piston % orthy through the sylindar 33 the expanding die 17 sed, the secondstage die 22 are draws speardly into the corrugated liner it and "iron out" the corregations is the limer, so that the expected liner may contect the famile well of the casing in which it is being installed. Poritiosed on the shaft below the expending member In is a communit torce spring number IT which is employed to true the expending number against the emphating name 22 with a substantially sometant force. The force exerted against the era sembles being substantially constant, the force transmitted through the arm members to the limy and to the during will be substantially enoriest so that either sticking of the tool in the casing or repture of the caring is precluded. Or course, the ctroe provided by the spring member is preselected so that the frictional



THE CONTRACTOR OF THE PROPERTY OF THE PROPERTY



forces between the tool and the liner and the presence emerted against the oseing are maintained at presentended safe levels. The constant force spring
masher easures that the context presence between the liner forming portion 20
of the same 22 is great enough to provide the desired deformation of the obs-

The equators force spring season 7 is alidebly nounted on the about 18 and hald between the expecting alongst 29 and a sylindrical lower choulder member 16 forcing a portion of a differential screw element 39 which beaments has looking on spring member 77 to short member 18. The differential screw alongst comprises about member 16 on the contribe of which are one mate threads 18s, the lower shoulder member 16 on the contribe of which are one hate threads 18s, the lower shoulder member 16 provided with threads on the short and the institute. The two scales of the lower shoulder member 18 and 11 po the contribe and the institute, respectively, to separe with threads on the short and the choulder. The two seeks of threads are scarred, such as square, solified equare, or force threads, to withstand very high loads and differ in pitch so that shoulder 35 is seemed appearily on the short 18 when the short is revolved relative to thinkle 11. The choulder 36 is secured to the short 16 by splings 43 so that it can slide longitudinally, but it is not tree to rotate on the short. Finally arisohed to the lower end of the thinkle is a friction severy, such as low intrings 48, a hydraulically estuated friction ped, or other rach device for frietionally compaging with the inside wall of the sacriat to occure the thinkle squaret totalism with respect to the short. Preferably, the direction of the shoulder nember 36 is the sacriat of the short threads 18s, e.g. right-hand threads 36s, with the pitch reside thing alone to unity. In this memors, clock-wise recollision of the short relative to the thinkle senses shoulder nember 35 to advance upwerd alightly and a compression loud is contribed upwardly on apring alasmod 37 to sense technique approximately 2.5-daches during threads on a chart approximately 1.7-inch oracle dissector and tive and threads and the shoulder and the shoulder and threads/inch aquare threads on a chart approximately 1.7-inch oracle dissector and tive and threads.



.....



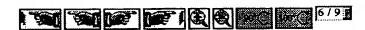
#### **736288**

Distant force spring element 37 comprises using element \$5, elvectageously consisting of a plurality of alongsted columns disposed around short is. Upper bearing plate smaler \$4 is in contact with the apper ends of the solumns and is althably positioned on shart is to transmit the force of the agring longitudinally against the bottom end of expendes assists \$6. Lower bearing plate number \$6 contacts the lower ands of the solumns and is noved appearedly along the seaft by lengthedical movement of lower smoulder \$6 on a result of revelving differential survey element \$7. Greeves \$7 are provided in seals of the bearing plates, to form an upper case and a lower race, into which the each of the column are inserted. These greens may be anaped to confurn with the shape of the column grain if seatred. A cover \$8 any be employed to axelade foreign matter from the spring mechanism and to protect the survey.

A means for limiting the deflection of the columns to required. Although the column element functions in a bunkled condition, application of . properties according local thereto would same total failure or repture of the columns. Therefore, a pair of stope by each tips are provided for this purpose. As shown, the stope ere rigidly connected to the bearing plates, and, in effort comprise upper and lower limiting slacres positioned on the shaft to alide longitudinally thereon. The ends of the stops may nowe toward, or enay from, each other so the Lord in the spring number vertee. Lover slaves also is prevented from moving down by lower shoulder 36 someouted to the shart 10. or, the spacing between the code in much as to limit the longitudinal I of the begring plate masters on they move together to prevent person deformation of the column alement by. Warrows alternative means for preventing damage to the column element way also be employed. For example, plas or rings sometad on the obert may serve as stops, or the cover 48 provided with estable commentates may be employed for this purpose to lists longitudical and/or lateral deflection of columns.

The columns of the column element 4) may be arranged erouse the grant 18, which as shown here forces a pursion of the body of the spring device, with made of the columns fitted in the recess 57. The solumns may be

- 6 -

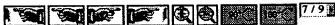




rative closely together as shows, or may be spaced around the race, with represented used between these to metateds the desired spacing. The number of construction. For example, the eleminates ratio of the column may be varied viduly, and the column mode may be round, flat, fixed or hinged. The preferred construction is a thin, element column with rounded ands, free to move withis the races shaped to the construct of the column ands. Returned which may be anticipatively supposed for the column are not. Returned which may be anticipated in the construct of the column and low alloy stocks, directly directly anticipated and alcohal-alreadom stainless proofer, various copper bear allegs, such as planeithe providing anticipation; the high sholed alloys and other similar internals providing anticipation; we changed to the the title tring greater than the thickness, and arranged so that the wider face of the unitame is normal to the dimester of the shaft. Thus, with sufficient compression loading, the columns backle, and band about the sain having the loars soment of inertia, e.g., outwartly may from the shaft 18.

For exemple, a group of columns 0.167-inch thick by 0.876-inch wife by 10.626-inches long, with the ands rounded, were februarded from A.f.S.I him wheel, quenched and draws at 575°F. Buth column was found to require a critical suspensation loading of 550 pounds in order to bookle the calumn. After bunkling, the columns were found to have a very flat spring characteristic, as shown in Figure 3, therein Fo is the critical bunkling load and point of represents the load and deflortion at which the stress is the extreme fibers of the solumn exceed the yield point of the material. Theoretically, the shape of this appring characteristic curve is described by curve Ch'ABC. Potota A and B represent typical working limits, which, af course, may be varied according to the application for which the spring is designed. For example, where a large number of flexing cycles are not moticipated, a working attrees just below the stress may be held to less than the enforcess limit of the material of construction. In the above-manticond teams, the lateral material or construction.

.....





approximately one inch, at which the longitudinal deflection was approximately 0.225 inches. From mere deflection to the assisten deflection, the 450-pound loading was found to be substantially constant.

In enother test a spring device was built, as shows, employing 20 columns, each having a critical buckling load of 1250 posses. The internal deflection was limited between 0 and about 1.00 inches by suprogriately positioning the stope. Once compressional loaning, the spring element buckled at schetamically 25,000 posses and from a longitudinal deflection of 0.04 inshed (buckling) to shoot 0.15 inches the load reasons substantially at 25,000

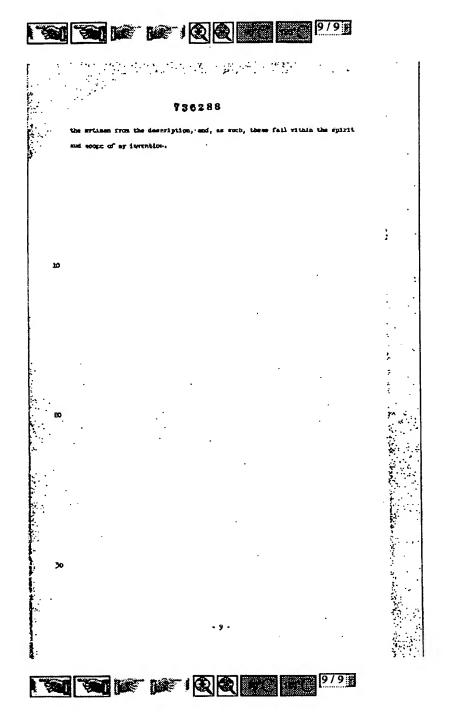
Of course, in conjuning a spring element as above it in advertages on to driven the greatest possible value of longitudine) defination for specified values of leberal deflection and articled buckling load, while unintending the stress level to the columns at a safe level. The preferred columns, therefore, are laminated, as shown in Figures 13 and 2, with multiple flat members

ps the operation of the above expending tool for setting a liner in well energy, the mede-up tool is lowered into the real as sectioned above, with the area 22 in the reviewed position. Then the tool is at the desired level, the well tubing is revelved. Too friction member of traggers with the wall of the earing and prevents thinkle hi from revolving. With several revolutions of the tubing, lower shoulder 35 is nevel assembly by differential server 39 to bush to open a server 37 which has a predeterminal writical bushling loos. This lead is transmitted upwardly against the lower and of expender 36, and the tapered surface is engaged with the tapered surface on the incides of the error 22 to urgs the turns outwardly with a substantially constant force proportional to the critical bushling look of the syring almost. Estimagently, the expending tool is passed through the liner to expend it in the casing in the senser described by at abotice.

the foregring description of a preferred embediment of my invocation.

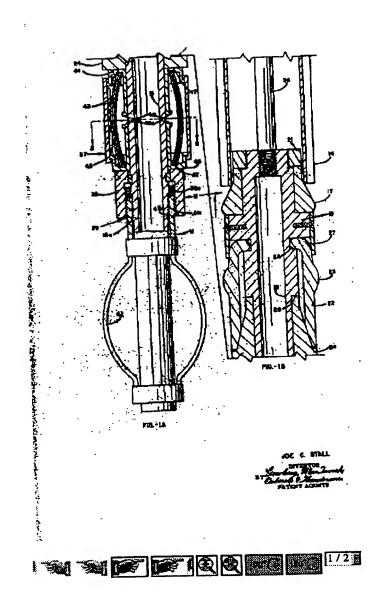
has been given for the purpose of examplification. It will be understood that
verious medifications in the detects of construction will become experent to

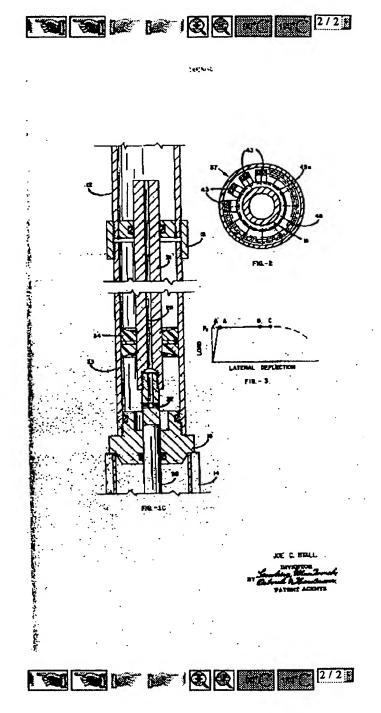
-8-





CUMMIA





# This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:
☐ BLACK BORDERS
☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
☐ FADED TEXT OR DRAWING
BLURRED OR ILLEGIBLE TEXT OR DRAWING
☐ SKEWED/SLANTED IMAGES
COLOR OR BLACK AND WHITE PHOTOGRAPHS
☐ GRAY SCALE DOCUMENTS
☐ LINES OR MARKS ON ORIGINAL DOCUMENT
REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
OTHER:

## IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.